Indian J. Applied & Pure Bio. Vol. 41(1), 347-356 (2026). **ISSN: 0970-2091**

Influence of Land Use Systems on Soil health in Behali Wildlife Sanctuary, North East India

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Abstract

Present study was carried out in five land use systems *e.g.* Agro forestry, grassland, mixed plantation, forest, home garden prevalent in and around the Behali Wildlife Sanctuary, Assam. Sampling was done by nestled plot technique. Soil textures were sandy loam and loamy fine sand in nature. The maximum sand percentage of texture is 88% and minimum is 76% while the maximum and minimum percentage of silt and clay are 20 & 4% (silt) and 8 & 4% (clay). Bulk density for different land use pattern are respectively agro forestry 1.009 (0-15 cm) and 1.038 (15-30 cm), grassland 1.072 (0-15 cm) and 1.165 (15-30 cm), Mixed plantation 1.107 (0-15 cm) and 0.931 (15-30 cm), Forest 1.058 (0-15 cm) and 1.097 (15-30 cm), Home garden 1.248 (0-15 cm) and 1.248 (15-30cm). Assam has significant proportion of area under forests and grassland which might have favoured considerably higher compared to the other NE states of India.

Key words : Deforestation, Leaching, Soil Fertility, Traditional conservation.

Soil health devastation has formed various serious issues, and it is a significant concern in the current stage. It decreases the soil's natural capacity to perform the normal ecologic functions and produce economic goods. Both soil degradation and restoration are mostly affected by different processes which are being regulated by natural and anthropogenic factors. The intensity of soil degradation is mostly affected by soil's susceptibility to degradative processes, duration of land use, land use, and the management.

North-eastern part of India is distinguished by unique characters such as high deforestation causing severe environmental

degradation, heavy soil erosion, loss of soil fertility and ecological imbalance[14]. It was found that average annual loss of top soil, phosphorus, organic carbon and potassium due to shifting cultivation were to the extent of 40900, 702.9, 0.15 and 7.5 kg per ha, respectively (ICAR, 1983). Different land use systems prevalent in the state and they have the impact on in north-east India, the soil quality and its health. Among the agricultural systems prevalent in hilly regions, Jhum cultivation is the most traditional and cultural integrated form. This system provides economic and ecological benefits and also much helpful to maintain fertility of soils[3]. Therefore, a new and eco-friendly land use model is essential instead of shifting cultivation to maintain ecological balance for conservation and management of natural resources.

Soil physical characteristics affect the pact of solid particles and their size. These are very important to regulate the movement of liquid and gases through soil particles. They are the result of soil parent material being affected by climatic factors, land use types, topography and life forms over a period of time. A change in any of these factors results in a difference in a type of soil. Assam is a state of the north eastern region of India which is blessed with large deposits of natural resources. The state is bestowed with natural vegetation as well as large reserve of mineral resources. Many factors are creating problems in forest and soil resources as well in Assam[6]. So, it is urgent need to study the soil health properly to conserve the natural resources.

Study area :

Present study was carried out in Behali Wildlife Sanctuary located in the Biswanath district of Assam. Sanctuary located between 25°45' - 26°00' N latitude and 91°45' 92°00' E longitude. Details sites includes Behali Wildlife Sanctuary (2,900 ha), Behali Reserve Forest (9,691 ha) and a portion of community forest west of the Umtrew river that is being acquired by the State Government. The area has a tropical monsoon climate. Annual rainfall is 2,500 mm. The mean monthly temperature varied from a maximum of 35°C in the month of August to a minimum of 13.3°C in January in the tropical landscape and a maximum temperature of 23.3°C in August and minimum temperature of 1.8°C was recorded in December in the montane subtropical landscape. The major part of the habitat is Tropical Moist Deciduous forest with patches of Tropical Semi-evergreen forest, especially in the river valleys and stream.

Five land use systems prevalent in and around the sanctuary, were selected for the details study *e.g.* Agro forestry, grassland, mixed plantation, forest, home garden. A total 5 replicates of soil samples were collected randomly from each land use from two depth (0 -15 cm, 15- 30 cm). Sampling was done by nestled plot technique. In each site, a plot of 20×20 m size was laid. Soil samples were collected by digging soil pits using soil auger after first removing surface vegetation and litter. Locations were identified with GPS record for each sampling point. Soil samples were weighed immediately upon returning from the ûeld to record their fresh weight. The collected soil samples were exposed to air and dried at room temperature. In laboratory, whole samples were spread on plates and air dried. After making all completely dried, the final weight of whole samples was determined.

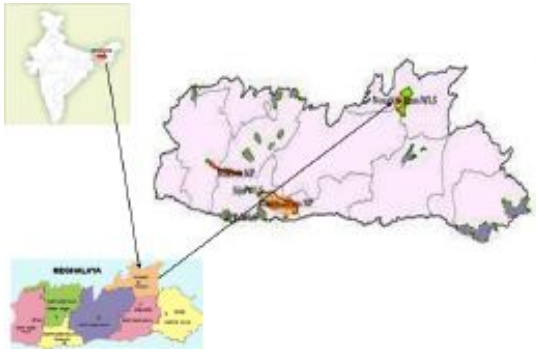

Figure 1. Map of study area in Assam

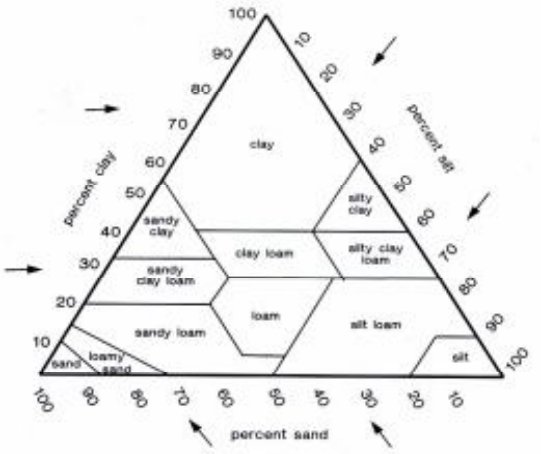

Figure 2. Soil textural triangle used for soil textural class from sand, slit and clay amount in the soil

Then, debris were removed (chunks of bark, wood, and stones), and entire soil samples were ground and sieved through a 2 mm mesh, and the entire sample was again weighed and mixed thoroughly.

Soil moisture content was determined by weight loss after drying 10 g of soil at 105° C for 24 hours and expressed as percentage dry weight. Different experiments such as water holding capacity, particle density, soil textures, bulk density etc. were determined by Keen's box method[1], Huque and Alam[11], Hygrometer method (Black[8]), Anderson and Ingram[2] respectively. Porosity of the soil samples was determined indirectly from the values of bulk density and particle density. Soil data obtained in this study were analyzed using SPSS statistical package for analysis of variance (ANOVA) to compare different soil physical characters.

Soil texture percentages for different land use pattern are shown in Table-1. From the experiment observed that the soil textures were Sandy Loam and Loamy Fine Sand in nature. Maximum sand proportion is 88% and smallest quantity is 76% at the same time as the most and lowest amount fraction of silt and clay are 20 & 4% (silt) and 8 & 4% (clay). Sand portion was found higher while percentage of silt and clay were comparatively found in low ranges. The soil texture of grassland came out to be Loamy Fine Sand as they have high percentage of sand type due to biotic pressure or due to interactive influence of topography, climate, fire and grazing. The soil texture is dominated by sand with a smaller fraction of clay and silt. The low content of silt and clay was found in the sampling sites which may be due to the presence of coal, stones or rock forming materials. Marshman and Marshall[13] have found out the significant relationship between the clay (%) and organic carbon in different abandoned areas. Thus, the low percentage in clay content may be due to the decrease in organic carbon. The lower level of organic carbon in mine overburden spoils might be due to the disruption of ecosystem functioning or loss of litter layer during

activities of mining. The fewer amounts of clay materials has many microspores through which water passes very slowly into the overburden materials as stated by many researchers. Elevated quantity of sand might be due to the consequence the streams and land filling by the relatively coarser materials. A positive correlation between clay content and porosity has been found in the present study. Positive correlation with sand and significant negative compaction that might have occurred in the lower horizons of the soil profiles with time.

The calculated bulk density for different land use pattern are respectively agro forestry 1.009 (0-15 cm) and 1.038 (15-30 cm), grassland 1.072 (0-15 cm) and 1.165 (15-30 cm), Mixed plantation 1.107 (0-15 cm) and 0.931 (15-30 cm), Forest 1.058 (0-15 cm) and 1.097 (15-30 cm), Home garden 1.248 (0-15 cm) and 1.248 (15-30cm). The bulk density was found to be highest at grassland (1.165) while it was found lowest at mixed plantation (0.931). The bulk density for natural forest was found 1.058. The results showed that the bulk density in the restored sites is increased as compared to that of natural forest.

Table-1. Soil textures and classes found in different land use systems in study area

Land use pattern	Depth (cm)	Clay %	Silt %	Sand %	Texture class
Agro-forestry	0-15	4	12	84	Loamy Fine Sand
	15-30	4	16	80	Loamy Fine Sand
Grassland	0-15	8	4	88	Loamy Fine Sand
	15-30	4	20	76	Loamy Fine Sand
Mixed plantation	0-15	8	8	84	Loamy Fine Sand
	15-30	8	16	76	Sandy Loam
Forest	0-15	8	8	84	Loamy Fine Sand
	15-30	8	12	80	Loamy Fine Sand
Home garden	0-15	8	16	76	Sandy Loam
	15-30	4	12	84	Loamy Fine Sand

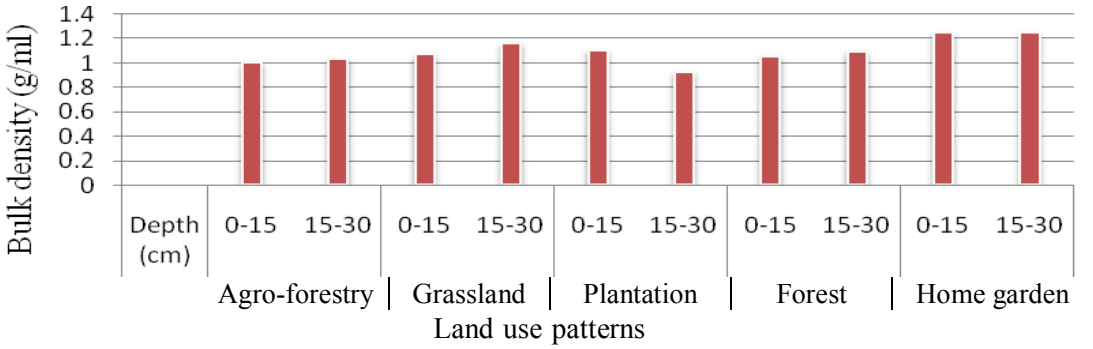

Figure 3. Percentage of Bulk density of different land use pattern

Result of bulk density is less than the result reported by Bhuyan *et al*.[7] from different land use patterns where the values lies between 0.72 and 1.04 g cm^{-3}. Maharana and Patel[12] also calculated the value of bulk density which ranges between 1.752 g/cm^3 and 1.275 g/cm^3 in coal mine overburden spoil. The soil of adjoining forest was found to be 1.47g/cm^3 as calculated by Shikha and Prafulla[15] while the value of restored area was between 1.54g/ cm 3and1.43g/cm^3. The areas of present study have lower bulk density as compared to the other calculated value which may be due to the enormous practice of coal mining or human activities in the area during the past years before restoration.

The porosity of the soil was calculated highest 3.57 at forest and lowest 0.98 at home garden. The porosity was in the order 1.16 (0-15cm) and 1.61 (15-30cm) at agro forestry, 3.12 (0-15cm) and 2.77 (15-30cm) at grassland, 2.77 (0-15cm) and 2.5 (15-30cm) at Mixed plantation, 3.57 (0-15cm) and 3.12 (15-30 cm) at forest, 1.61 (0-15 cm) and 0.98 (15-30 cm) at home garden with respect to the parameter in figure 4. The decline in total porosity was the result of a reduction in pore size distribution. The results showed the improvement in the soil porosity of restored sites with increasing years of restoration. The increase in total porosity was the result of the increase in pore size distribution. The highest porosity was recorded as 46.12 mg/m^3 in coal mining area in Dehradun, Shikha and Prafulla[15]. Porosity ranges between 60.23 mg/m^3 and 72.3 mg/m^3 in different land patterns as calculated by Bhuyan and Momin[4]. The porosity show high value in present study comparing with calculated values of different areas.

The highest water holding capacity was 74 % (0-15 depth) obtained at mixed plantation and 82% (15-30 depth) obtained at Home garden and the lowest percentage was 54% (0-15depth) obtained at Agro-forestry and 62% (15-30cm) which is obtained at Grassland. The water holding capacity for an adjoining forest area was in both the upper and the lower depth. This shows that the mixed plantation of restoration area has better result than the Agro-forestry area and the recovery is enough for vegetation growth and for the success of eco-restoration. Patel (2013) calculated 46.348% of water holding capacity in coal over burden area while the calculated value of maximum water holding capacity by Singh and Juwarkar[16] was 48.58% in dumpsites. Present values are within the ranges found in different land use patterns studied by Bhuyan *et al*.,[5] in Arunachal Pradesh.

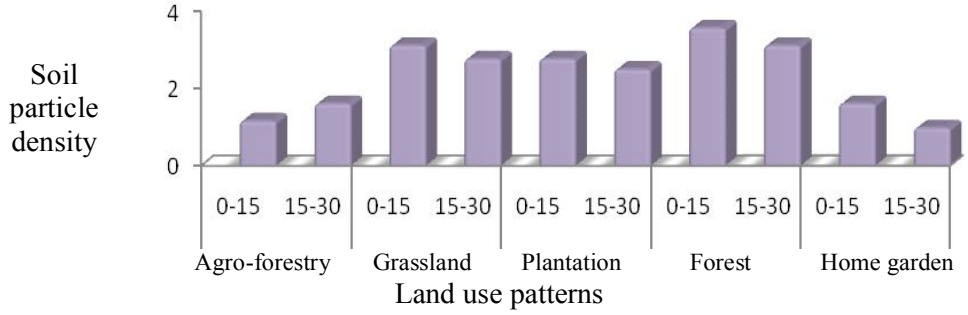

Figure 4. Soil particle density of different collected land use pattern.

The maximum moisture content was found at home garden 7.783% (0-15cm) and 8.141% (15-30 cm) the minimum moisture content was 7.68% (0-15 cm) at Grassland and 6.167 % (15-30 cm) at agro forestry. Swer and Singh[17] calculated the soil moisture content of coal mining areas in Jaintia Hills where the values ranges between 0.4 to 9.2%. Thus, it can be said that the moisture content in the present study of restored area has better result which shows quite improvement in the soil properties as compared to mining area of Jaintia Hills, Assam. Physical properties of mined spoil areas may have low clay fraction, low water holding capacity and high bulk density while the physical properties of different land use pattern area have high clay fraction, high water holding capacity and low bulk density.

The mining activities have resulted in great loss of forest cover and poor soil properties, so ecological restoration has become an urgent need in the mining area. The present study revealed that the soils of different restored sites are Loamy Fine Sand as the soil texture class has more percentage of sand. Further, an increased trend of bulk density was observed with the increasing restored sites. The bulk density is important as it regulates space, air and water availability to soil organism (Foissner, 1992).

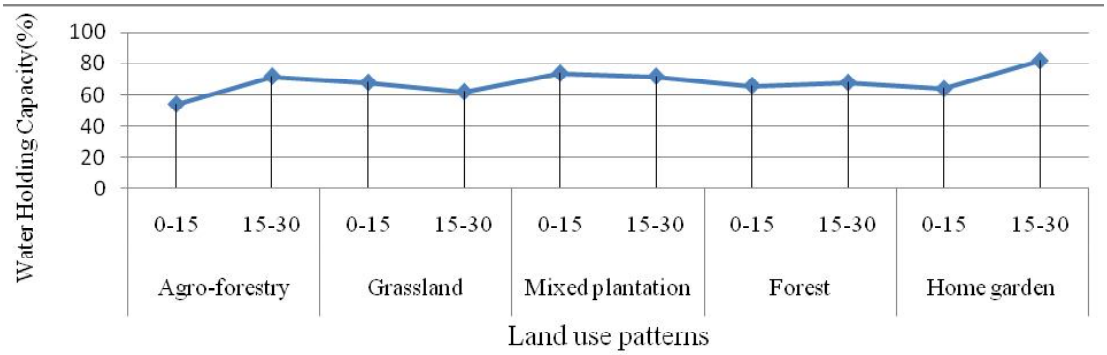

Figure 5. Soil water holding capacity of different collected land use pattern.

In soil restoration, soil texture distribution play a major factor influencing bulk density, water holding capacity and soil moisture availability. The increase in clay fraction increases the organic carbon and hence decreases the soil bulk density. Clay also play an important role as an absorption sink for organic matter[13]. The soil bulk density increases with the decrease level of clay fraction. Turn down in bulk density decrease soil compactness because of micro pore space formation (Brady, 1990). The soil porosity of the restored area increases with increasing years of restoration which can be due to the increase in organic matter as reported by many researchers. The percentage of water holding capacity was found quite high in the restored areas. Therefore, the further study showed recovery in the porosity, bulk density and water holding capacity in different restored sites. The soil moisture content increases with the progressive increased of restored sites which may be due to the vegetation over the surrounding areas. The accumulation of vegetation biomass

influences the vegetation growth and soil properties in the mining area. The outcome of the successful eco-restoration usually depends on the nature of plant distribution in the restored sites[10]. Thus, the soil physical property increases with increasing age of restoration providing succession restoration in the land use system areas.

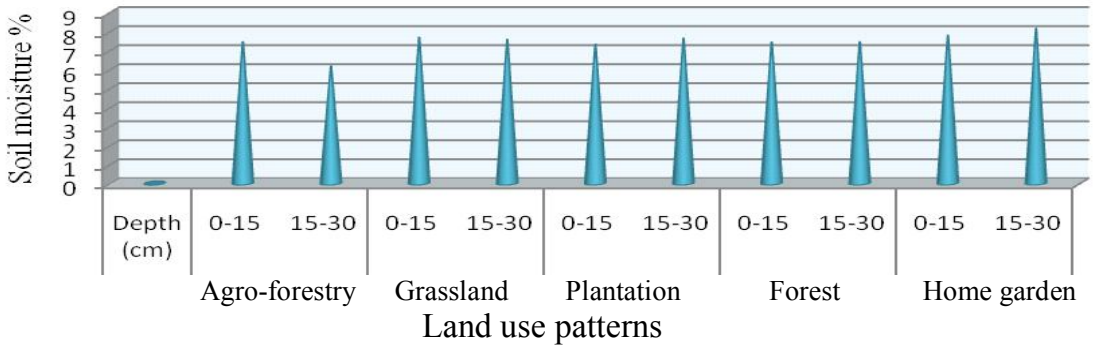

Figure 6. Moisture content of soils % of diverse land use models

The study area represents a unique set of geographical and biophysical features which are closely linked with the cultural and social parameters of the locals. Due to land use pattern of agro forestry, home garden, etc. practiced by the farmers, large patches of cultivable land are openly exploited through unscientific and age old practice of farming. This has been detrimental not only to crop production but also the immediate environment and biodiversity. Constructive plans for conservation and sustainable production is the need of the hour.

Table-2. Correlation coefficient ('r') of soil characteristics

Parameter	Depth (cm)	Particle density	Porosity	WHC	Sand	Clay	BD
Particle density	0-15	-0.48	0.53	0.24	-0.51*	0.50	-0.60*
	15-30	0.40*	0.56	-0.41*	0.67*	0.17	0.45
Porosity	0-15			-0.71	0.35	-0.24	0.68*
	15-30			-0.23	0.38	0.31	0.73*
WHC	0-15				-0.44	0.46*	-0.34
	15-30				0.59	0.41	0.48
Sand	0-15					0.45	-0.59
	15-30					-0.34	0.38
Clay	0-15						0.21
	15-30						0.47

This is where the present study reveals the effectiveness that helps in maintaining ecological balance. It is observed that there is good potential for and plantations. The land use plan prepared in the study also focuses on conservation of the existing forests including mixed plantation to maintain ecological balance while taking up improved and alternate farming practices. Different indigenous forms of agricultural systems are attached with the social, cultural and traditions of the rural people; for this reason new, innovative, integrated model best suited for the locality may be applied scientifically for the livelihood support.

Table-3. Two way ANOVA showing the effect of land use patterns and soil depths on soil characters

Variable	Particle density			Sand			WHC			BD		
	df	F-ratio	P	df	F-ratio	P	df	F-ratio	P	df	F-ratio	P
Land use patterns	5	1.389	0.116	5	0.247	0.217	5	0.290	0.155	5	0.290	1.470
Depth	1	0.340	1.435	1	0.425	0.538	1	0.57	0.124	1	0.404	0.552
Land use × Depth	5	0.412	1.577	5	1.470	0.315	5	0.116	0.57	5	0.389	0.115

df- degree of freedom, P-significant level.

Thus, the study of soil characteristics can play an important role with its ability to incorporate both spatial and non-spatial data to generate realistic and effective land use plan. On view point, the correct approach to improved land use planning lies in recognizing the importance of various natural resources in sustaining the livelihood of the locals and considering its optimized utilization and strategic management. The context of soil characteristics of different land use pattern in the present study has highlighted the capability of remote sensing for formulating viable plans that adheres to identify the potential of land resources for extensive agriculture and horticulture crop cultivation in suitable areas identified through this technology.

Agro-forestry is a varied, complex and sustainable production system. In this region trees are deliberately grown with various crop and livestock under traditional production systems. Some of the systems developed for the region have positive impact on the soil and water resources. These systems need to be further improved with suitable technological interventions to carter the needs of the local populace and help in improving the socio-economic conditions of the farming communities.

Land-use system practices across the Assam, interaction among several factors ranging from variation in soil texture, climatic variables mainly rainfall and temperature, topography, and land-use practices might have influenced the significant variation in inventories across Assam state. It has significant

proportion of area under forests and grassland which might have favoured considerably higher compared to the other NE states of India. In the case of Assam and Tripura, the content was low primarily due to their geographic location at lower latitude and altitude. On the basis of observation from the present study, it is apparent that mixed plantation or Forest area has significantly improved soil physical characteristics particularly decreasing bulk density and erosion respectively and porosity aggregate stability and available soil moisture. However, improvement in soil properties under the humid sub-tropical climate of the Himalayan region northeastern, where soil erosion is the main land degradative process in agro forestry system is a viable option for eco-restoration, maintenance of soil resources and could sustain long-term soil and timber productivity so as to improve food security of the poor tribal farmers of northeast India.

Authors are thankful to local people for their assistance during the field work. Authors are also thankful to the department botany, PDUAM-Behali, staff, laboratory bearer for the assistance during the laboratory experiment.

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